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## THE SURGICAL TREATMENT OF BRAIN ABSCESS BY EXPOSURE AND ENUCLEATION

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FROM THE NEUROSURGICAL SERVICES OF THE HOSPITAL OF THE UNIVERSITY OF PENNSYLVANIA AND  
GRADUATE HOSPITAL OF THE UNIVERSITY OF PENNSYLVANIA, PHILADELPHIA, PA.

THE PROCEDURE of enucleation of an "encapsulated" brain abscess was considered, by Sargent,<sup>1</sup> to be the best method of treatment. He reported, in 1928, without giving details, five patients successfully treated in whom the abscess had been removed. More recently, Vincent<sup>2</sup> has renewed the interest in this method of treatment and has proved its value. Up to the present time, he has reported five patients. The abscess, in each instance, was exposed and removed without rupture. By our successful use of this method of treatment for brain abscess in six of seven patients, we wish to add further support to the procedure of complete enucleation, and from the experience gained, outline the surgical management of a patient in whom the diagnosis has been made.

**Case 1.\*—Synopsis:** Intracranial symptoms for six weeks. Signs of intracranial hypertension and bilateral sixth and seventh cranial nerve involvement. Ventriculogram: Lesion in right frontoparietal lobes. Craniotomy and complete removal without rupture of a walled abscess. Recovery.

E. S., Hosp. No. 125122, female, age 20, was admitted to the Graduate Hospital, September 12, 1936, having been referred by Dr. J. C. Yaskin, Philadelphia, Pa. About three months prior to admission, the patient had had a tonsillectomy performed, under local anesthesia, without any untoward effects. Six weeks later she began complaining of headache and somewhat later of diplopia, loss of vision and vomiting. During the few days preceding admission to the hospital the pain in the head had become more severe.

**Physical Examination.**—Temperature 99.3° F., pulse 64, respirations 22. Neurologically, she was mentally clear, had some rigidity of the neck, a bilateral Kernig, a bilateral papilledema of about three to four diopters, a cut in the left temporal field, weakness of both external recti muscles, more marked on the left than on the right, a paralysis of both seventh nerves, more marked on the right than on the left, and no significant changes in the extremities. The spinal fluid pressure was 350 Mm. of water, and the spinal fluid showed five lymphocytes.

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Submitted for publication June 8, 1939.

\* Previously reported as Case 1, Brain Abscess of Undetermined Etiology, J. C. Yaskin, F. C. Grant, and R. A. Groff, ANNALS OF SURGERY, 107, 492, April, 1938.

The white blood count was 12,800; with a mild secondary anemia. The urinalysis was negative. The blood Wassermann was negative. The stools showed ova and segments of *Taenia saginata*; the patient's father recalled that she had had a tapeworm many years ago. Roentgenographic examination of the skull and the paranasal sinuses revealed no abnormalities. A second lumbar puncture revealed a pressure of 700 Mm. of water, and the spinal fluid showed 15 cells.

*Operation.*—September 19, 1936: Dr. F. C. Grant did a ventriculogram which showed a mass lesion on the right side, probably in the frontoparietal region. A right fronto-temporal bone flap was reflected. The dura was extremely tense, and upon its reflection, the sylvian fissure was seen to be pushed up by a mass beneath the surface and within the substance of the tip of the right temporal lobe (Fig. 1). A transcortical incision was made over the tumor which was removed without rupture. It measured  $3\frac{1}{2} \times 4 \times 5$  cm.

*Pathologic Examination.*—Section of the tumor revealed an abscess filled with a fibropurulent, thick exudate. The wall was 0.5 cm. thick. Microscopic examination of the

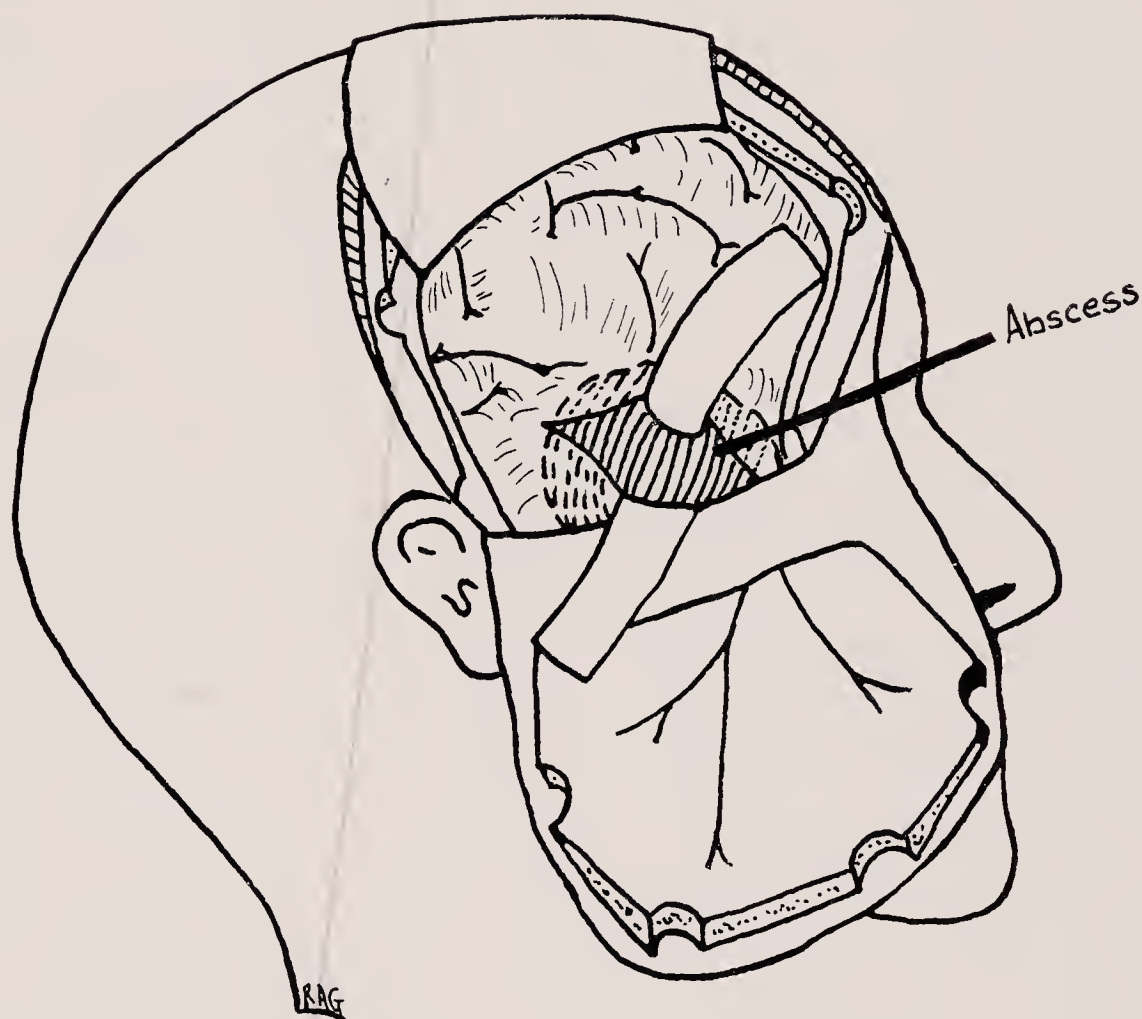


FIG. 1.—Case 1: Schematic diagram showing location of abscess in right temporal lobe.

wall showed it to be composed of a stout fibrous stroma, in which many short glial fibrils were to be seen together with numerous blood vessels, many of which showed proliferative changes. Plasma cells, lymphocytes, and old polymorphonuclear cells were present.

*Subsequent Course.*—The patient made a rapid and uneventful convalescence. The neurologic signs disappeared and she has remained well to date.

*COMMENT.*—The history given by this patient should have suggested the possibility of brain abscess. The relatively long interval between the tonsillectomy and the development of intracranial symptoms seemed to exclude this diagnosis. The bilateral sixth and seventh cranial nerve impairment, without other signs except intracranial hypertension, made ventriculography necessary. The fortunate surgical management of the lesion by intact, complete removal prevented the fatal complication—meningitis. The smooth un-



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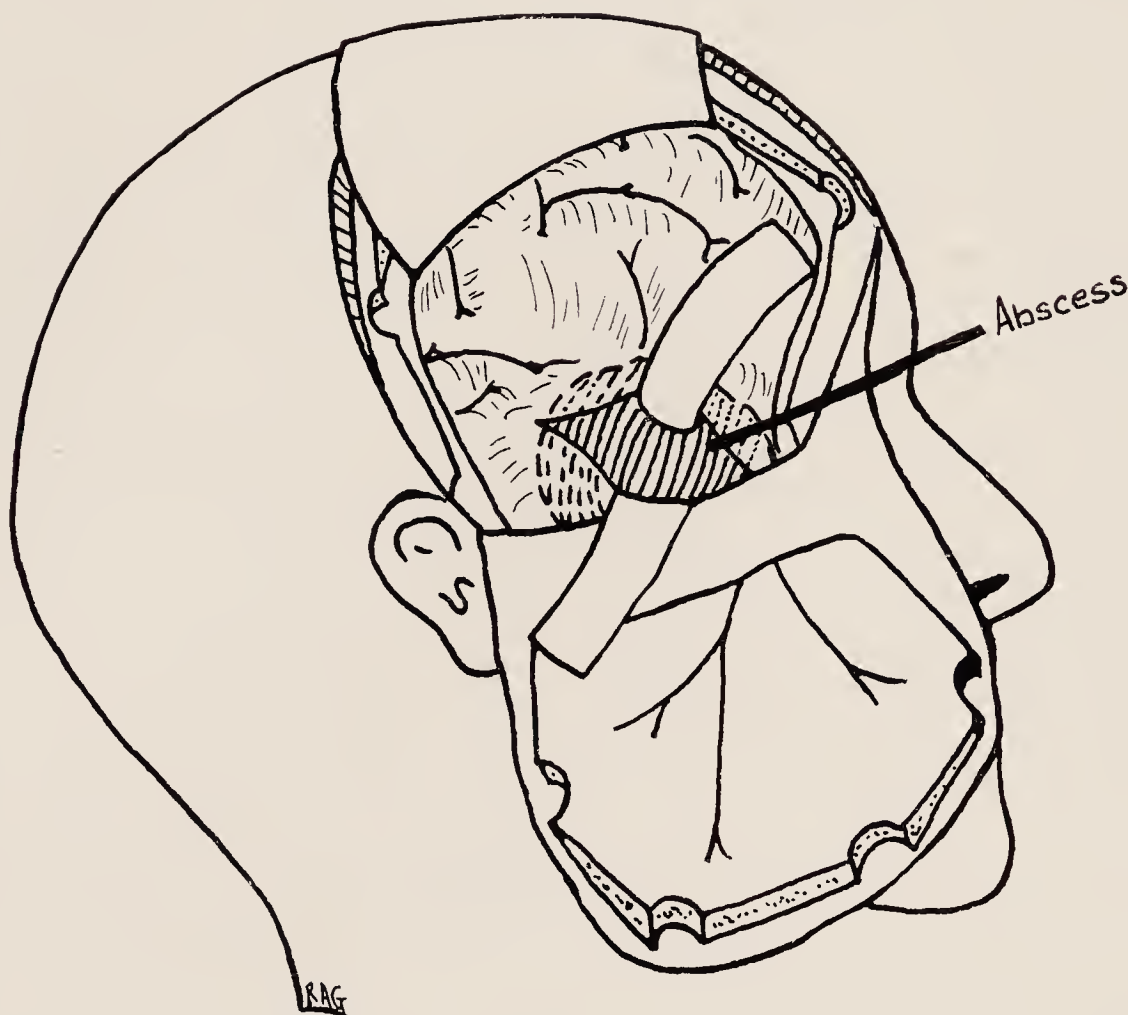


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**Case 2.**—*Synopsis: Symptoms for 14 weeks. Signs suggestive of expanding left cerebral lesion. Cannula struck abscess during ventriculography. Abscess exposed and removed without rupture. Recovery.*

J. F. M., Hosp. No. 35238, male, age 26, was admitted to the University Hospital, January 12, 1937, having been referred to Dr. F. C. Grant by Dr. Marshall W. Dyer, Syracuse, N. Y. The patient was well until 14 weeks before admission to the hospital, when he began complaining of projectile vomiting. This vomiting bore no relationship to meals or time of day and continued up until the time of admission. One week after the onset he developed left-sided headache which subsequently became generalized. Shortly afterward he had periodic attacks of dimness of vision. While walking he noticed he tended to deviate to the right and on numerous occasions became dizzy when bending over.

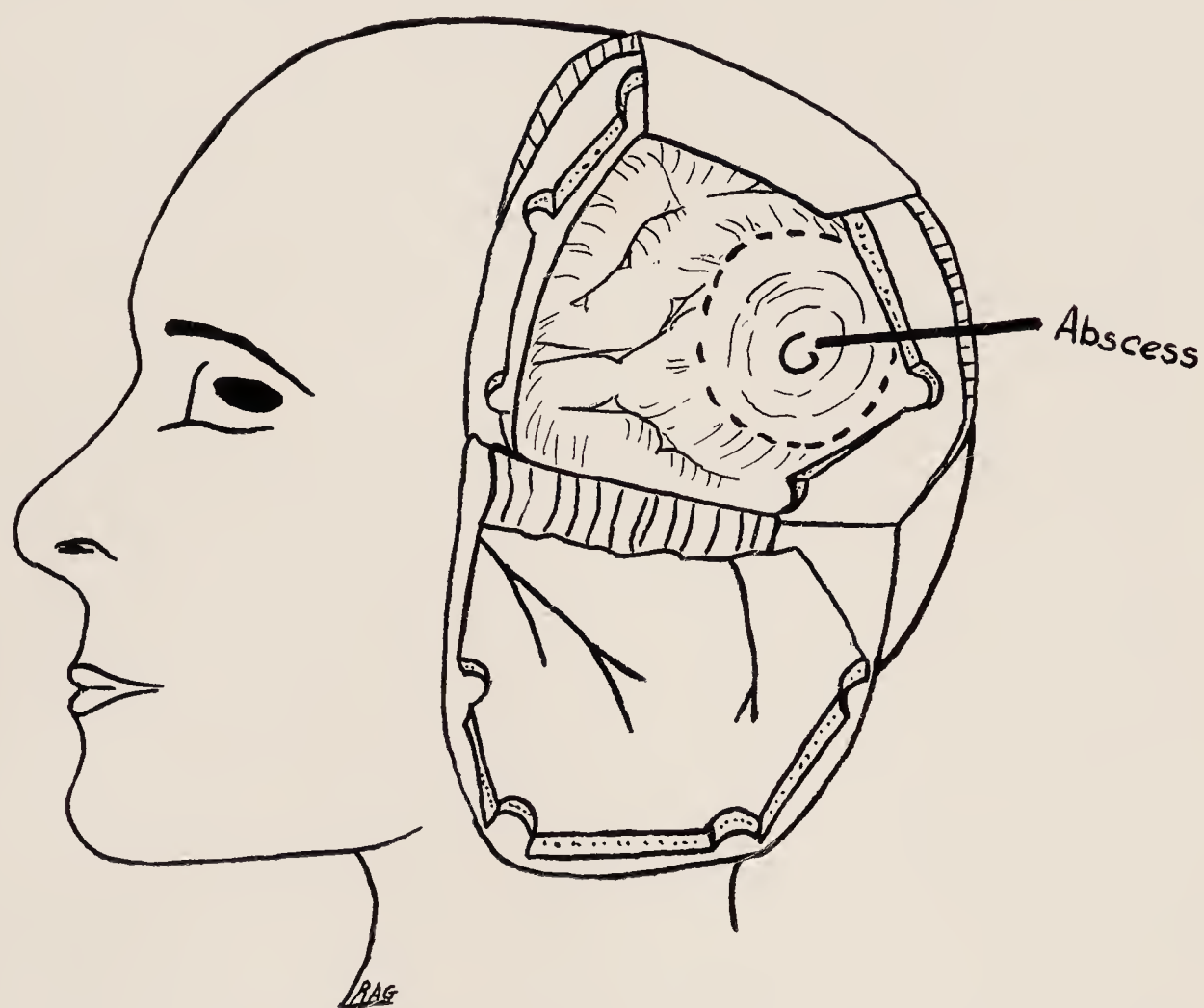


FIG. 2.—Case 2: Schematic diagram showing location of abscess in left occipital lobe.

*Physical Examination.*—The patient was normal except for dental and tonsillar sepsis. Neurologic examination revealed a fair mental orientation, dysarthria with test phrases, left sixth nerve palsy, choked disks of four to five diopters, positive tremor sign on the right, abortive ankle clonus on the right together with mild increase in reflexes on the right side of the body, dysnergia in finger to nose test on both sides, unsteady gait, and poor associated movements on the right side. Temperature, pulse and respirations were normal. The leukocyte count 10,600, and the Wassermann negative. The visual fields showed a marked contraction of both temporal fields, especially on the right, and a complete right homonymous hemianopia. Roentgenograms of the skull showed erosion of the posterior clinoids and dorsum of the sella with some forward displacement of the top of the dorsum.

*Operation.*—January 22, 1937: Dr. F. C. Grant performed a ventriculogram for the purpose of localization. A solid mass was encountered by the cannula when attempting to enter the posterior horn of the left lateral ventricle. Predicated upon this, a left

ANNALS OF SURGERY.

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occipitoparietal bone flap was reflected. On the cortex, in the occipital lobe (Fig. 2), a grayish-yellow, massive tumor was exposed. This tumor was carefully dissected from its bed without damaging it. After complete hemostasis had been secured, the wound was closed. The tumor measured approximately 6x4x4 cm.

*Pathologic Examination.*—Section of the tumor revealed it to be an abscess containing thick greenish pus. The wall was quite thick and contained a few large blood vessels. Microscopic examination of the wall showed it to be composed of a dense fibrous structure arranged in parallel rows. Among these fibers were numerous fibroblasts and scattered polynuclear cells.

The patient made a rapid and uneventful convalescence. On discharge practically all of the neurologic signs had disappeared but the disks showed a choking of two diopters.

*Subsequent Course.*—The patient has been seen since operation. The vision and visual fields have improved. However, in the six months following removal of the abscess, three generalized major convulsions have occurred. He was given small amounts of phenobarbital and has had no attacks for the past 18 months.

**COMMENT.**—This patient presented essentially the same problem as the case just described. The history was longer and the neurologic signs were suggestive but not conclusive of exact localization. The abscess was exposed by an osteoplastic flap and completely removed without damage. The rapid convalescence and the necessity of only 20 days' hospitalization further emphasize the rationale of this method of treatment.

**Case 3.**—*Synopsis: Intracranial symptoms for two weeks following mild head injury and streptococcic sore throat. Signs of intracranial hypertension and a right parietal lesion. Craniotomy, tap of abscess by exploring cannula, and complete enucleation. Recovery.*

S. K., Hosp. No. 39361, male, age 21, was admitted to the University Hospital, June 6, 1938, having been referred by Dr. C. C. Neff, York, Pa. The patient had been perfectly well until two weeks before admission, when he bumped his head on a beam. He did not become unconscious nor were there any ill effects from this accident. Shortly afterward the patient developed a sore throat which lasted one week. The infection was alleged to be caused by the streptococcus. One week before admission he had an attack in which both arms and legs "stiffened," but no loss of consciousness occurred. This attack began in the left arm and spread to involve the rest of the body. It lasted approximately ten minutes. During the next three days he had three to four similar attacks. Since then the patient has become progressively more dizzy, especially when attempting to walk. At about the same time these attacks began he developed right frontal headaches. For the several days before admission the left arm and hand had become weak.

*Physical Examination.*—The patient was acutely ill. Temperature 99° F., pulse 80, respirations 20. Neurologic examination: The patient was definitely lethargic, the eye-grounds showed a bilateral papilledema of between two to three diopters. The visual fields, to gross tests, were normal. There was a left central facial weakness. The corneal reflex was decreased on the left. The left arm and hand were weak in all movements and a similar but less marked weakness was demonstrated in the left leg. Reflexes in the left arm were increased over those in the right. In the lower extremities, the reflexes were bilaterally exaggerated but equal. A sustained ankle clonus was present on both sides. The left side of the body, including the face, showed a reduction to all forms of sensation, and the left hand showed a loss of stereognostic sense. White blood count 20,300; spinal fluid pressure was 300 Mm. of water, and showed four cells per cubic millimeter.

*Operation.*—June 2, 1938: Dr. L. Weinberger performed bilateral frontal and parietal trephines. No hematoma was found. The ventricles were tapped and the left was found to be larger than the right.

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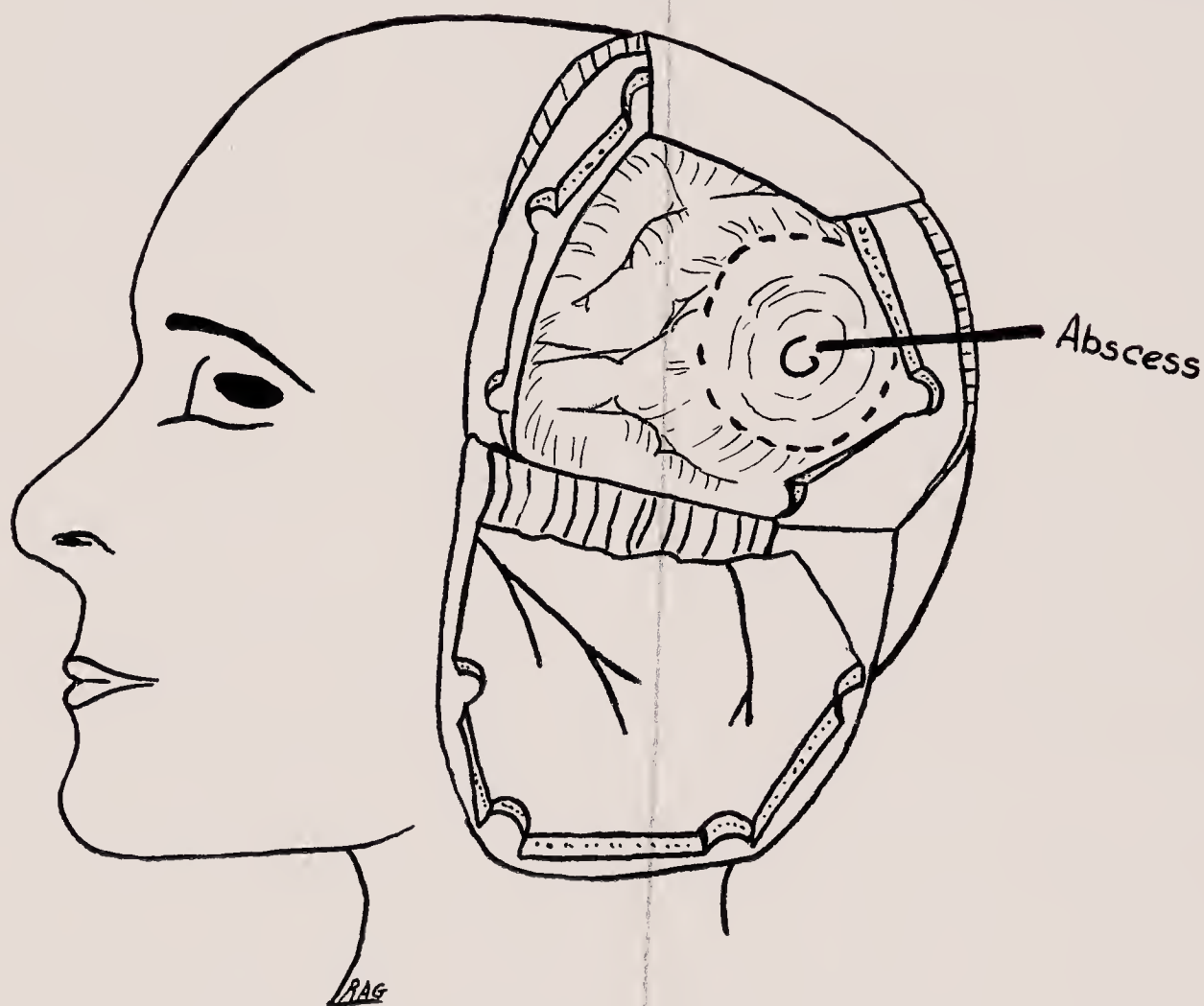


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brain was under marked tension and the dura was opened rapidly. A subcortical lesion was indicated by widening of the gyri in the parietal and temporal lobes. A cannula was introduced in this area and it entered an abscess (Fig. 3). Two cubic centimeters of pus were obtained. The cannula was withdrawn. The dura was closed except at the base of the defect over the temporal lobe beneath the temporal muscle. The dura was then reopened over the abscess and a transcortical incision was made down to the wall. The abscess was enucleated without rupture. The resulting cavity in the brain was packed with gauze soaked in azochloramine and an incision made in the scalp for its removal at a future time. The bone flap and scalp were replaced and the scalp closed by interrupted silk sutures.

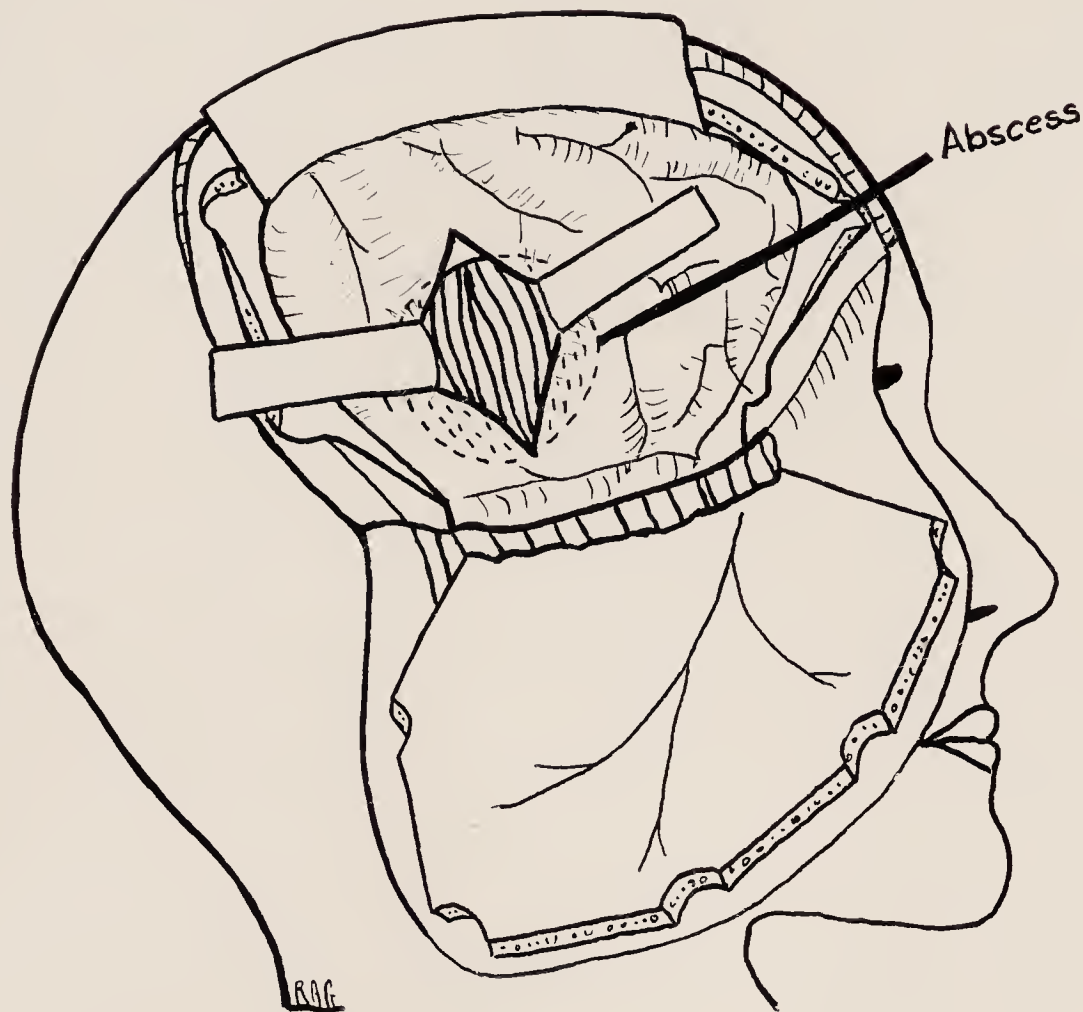


FIG. 3.—Case 3: Schematic diagram showing location of abscess in right parietotemporal lobes.

*Pathologic Examination.*—The abscess (Fig. 3) measured  $5 \times 4 \times 2\frac{1}{2}$  cm. The wall varied in thickness from 3 to 5 Mm. The pus was thick, greenish and foul-smelling. The organism was a gram-negative rod resembling *Haemophilus*. Microscopically, the wall consisted of a dense layer of collagen with few vessels and numerous polymorphonuclear cells.

The packing was removed on the second day but the wound continued to drain for 15 days and then healed. Pressure was controlled by daily lumbar punctures. The weakness on the left side of the body was more pronounced following operation but subsequently improved so that he was able to walk on the ninth postoperative day.

*Subsequent Course.*—Follow-up examinations up to the present time showed that the weakness of the left leg has cleared completely, the arm remains slightly weak and at about monthly intervals the patient has sensory jacksonian attacks in the left arm. Otherwise he feels well.

*COMMENT.*—The particular problem this case presented was to determine the course to be adopted when an abscess is tapped during a craniotomy. In this patient, the cannula was removed and the dura closed in order to maintain

pressure sufficient to keep the subarachnoid space closed. An opening was then made through the dura and brain down to the wall. The abscess was removed through this opening. To prevent possible spread of infection, the cavity was packed with gauze saturated with azochloramine. This course of treatment was effective in preventing meningitis in this patient.

**Case 4.**—*Synopsis: Symptoms of intracranial involvement for two weeks. Signs of intracranial hypertension. Ventriculogram. Right frontoparietal craniotomy and exposure of abscess. Subsequent removal of wall. Second admission: Removal of infected bone flap. Recovery.*

W. T., Hosp. No. 137004, male, age 11, was admitted to the Graduate Hospital, August 25, 1938, having been referred by Dr. Mark D. Grim, Oley, Pa. The patient had been in good health until eight weeks before admission to the hospital, when he developed

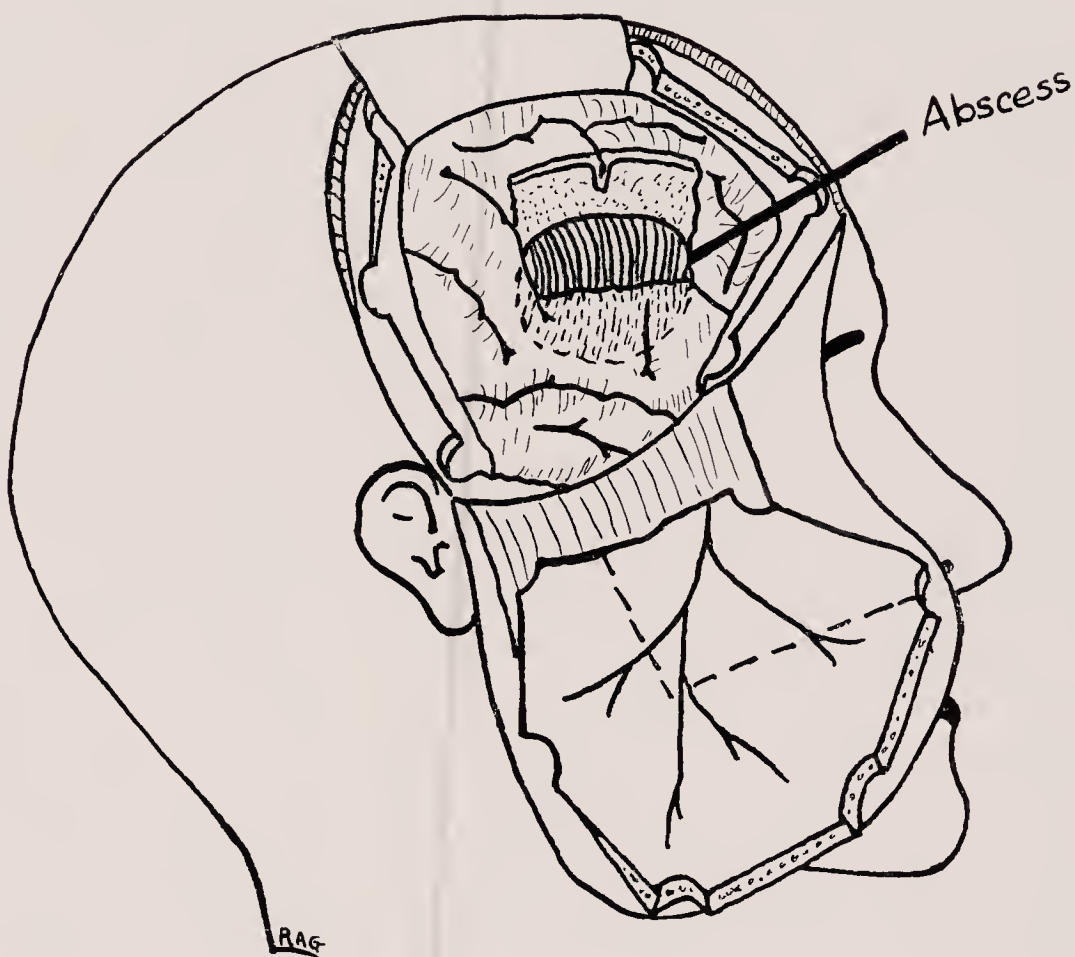


FIG. 4.—Case 4: Schematic diagram showing location of abscess deep in right frontal lobe.

frontal headache and a fever of  $101^{\circ}$  F. These symptoms continued for ten days, when he had a generalized convulsion. Following the convulsion all symptoms subsided. The patient was then well until two weeks before admission, when headache and vomiting began and continued up until admission to the hospital. One week before admission, examination of the eyegrounds showed papilledema of both optic disks.

*Physical Examination.*—This was essentially negative, and the neurologic examination was likewise negative except for a bilateral papilledema of four diopters. Visual fields were full. Barany examination was suggestive of an intracranial lesion. Roentgenograms of the skull and paranasal sinuses were entirely negative. White blood count 10,600; the blood Wassermann was negative.

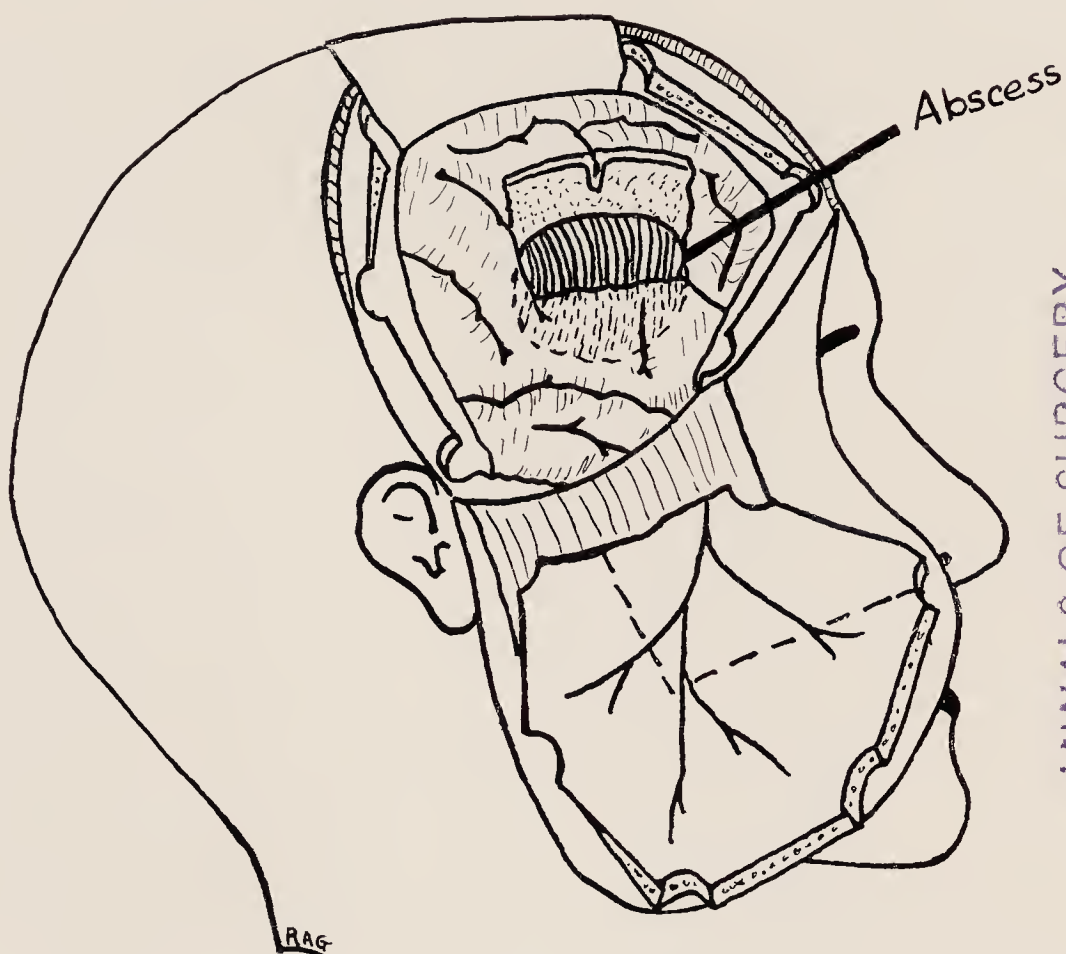
*Operation.*—August 1, 1938: Dr. R. A. Groff performed a ventriculogram which demonstrated a lesion deep in the right frontal lobe. A right frontoparietal bone flap was reflected and no surface tumor was seen. A mass (Fig. 4) was felt 3.5 cm. below the surface of the frontal lobe in its posterior portion by an exploratory cannula. A block of cortex measuring 5 cm. square was removed over the lesion. A lumbar puncture needle was introduced into the lesion and 1 cc. of thick, yellow pus was obtained. Examination



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ANNALS OF SURGERY.

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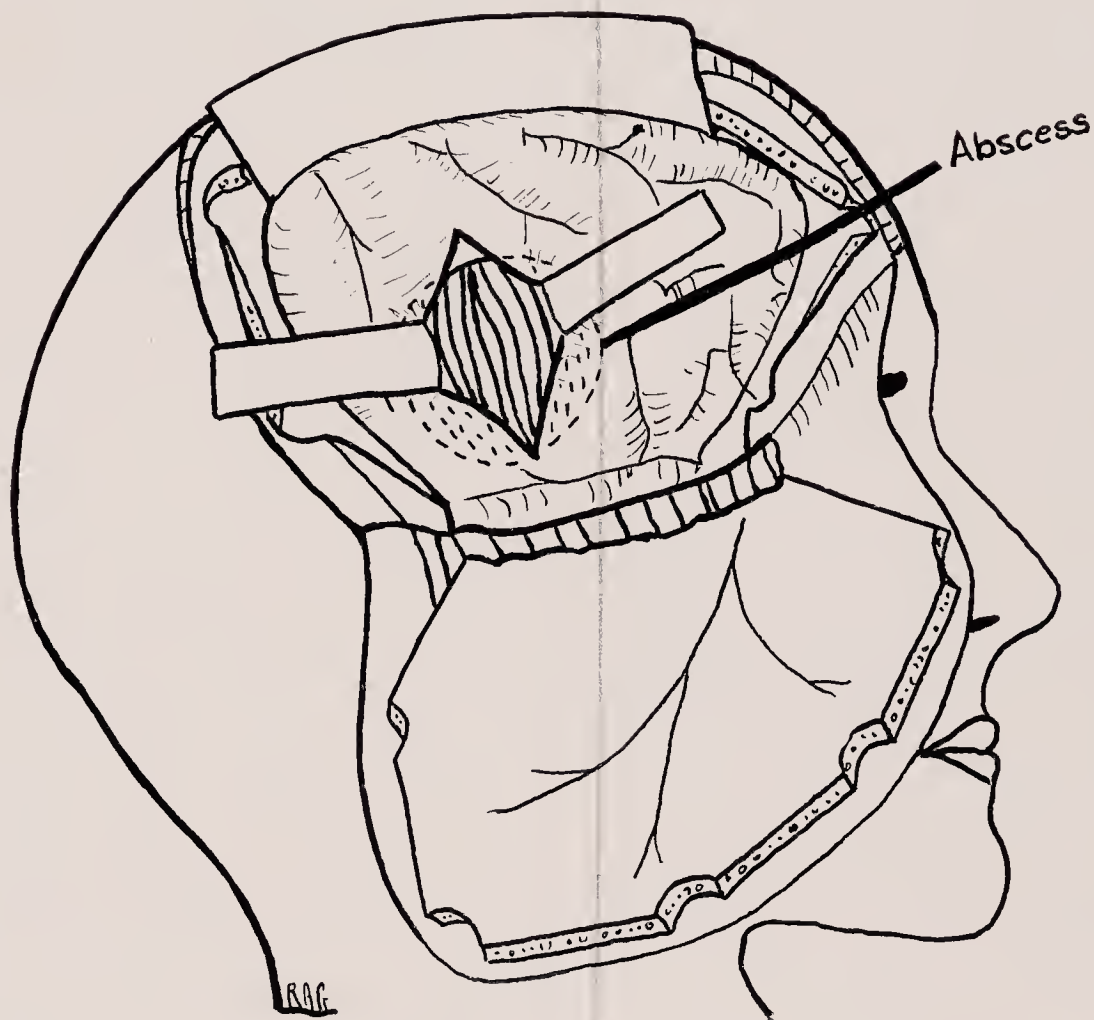


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of this pus showed many gram-positive Cocci. An attempt was made to enucleate the abscess but the wall was too thin. Sutures were then placed in the wall at its thickest portion. The dura and bone were removed over the lesion. Iodoform packing was placed in the cavity over the abscess and brought out through a separate overlying scalp wound. The remaining dura was sutured in position, the bone flap wired to the skull, and the scalp closed in two layers.

*Postoperative Course.*—The night of the operation, the abscess had pushed its way to the scalp edge, displacing the packing. A suction tip was inserted in a seepage point on the wall and two ounces of pus were removed. The opening in the wall was enlarged and packed tightly with iodoform gauze. Six days later, after signs of infection had subsided, the wall was teased out of its bed through the overlying scalp wound. During this maneuver the ventricle ruptured into the wound. This complication was treated by antiseptics to the surrounding scalp and application of sterile dressings. The cerebrospinal fluid leak continued for ten days and then stopped. Several days later pus was evacuated



FIG. 5.—Case 2: Postoperative photograph of patient showing well-healed scar following a left occipital craniotomy.

from above the right eyebrow and a sponge removed which had been left in at the time of operation. Both wounds healed subsequently and the boy was discharged 38 days after operation.

*Subsequent Course.*—On November 7, 1938, the patient was readmitted because of a draining sinus along the upper medial limb of the scalp incision. Roentgenograms of the skull demonstrated an osteomyelitis of the bone flap. The diseased bone was removed and the patient discharged 58 days later with wound healed except for a small area at the site of the previous drainage tract. Since discharge (Fig. 5) from the hospital following his second admission, the wound has healed and the boy remains well and is attending school.

*COMMENT.*—The surgical problem presented by this patient was similar in many respects to Case 3, except that the wall was too thin to permit enucleation at the time of the original operation. The fact that the abscess migrated to the surface indicated that the abscess would probably have delivered itself if sufficient time had been given. Kahn<sup>3</sup> has demonstrated this very dramati-



cally. The abscess cavity, however, was evacuated of its contents, packed with iodoform gauze and after evidences of active infection subsided, its wall was removed. The cerebrospinal fluid leak which followed was alarming but stopped under conservative treatment. The subsequent development of an infection in the bone flap was caused by an overlooked sponge.

**Case 5.**—*Synopsis: Severe head injury followed by symptoms and signs of focal brain disease with intracranial hypertension. Exploratory trephines and bilateral subtemporal decompression. Removal of three abscesses in stages through left subtemporal decompression.*

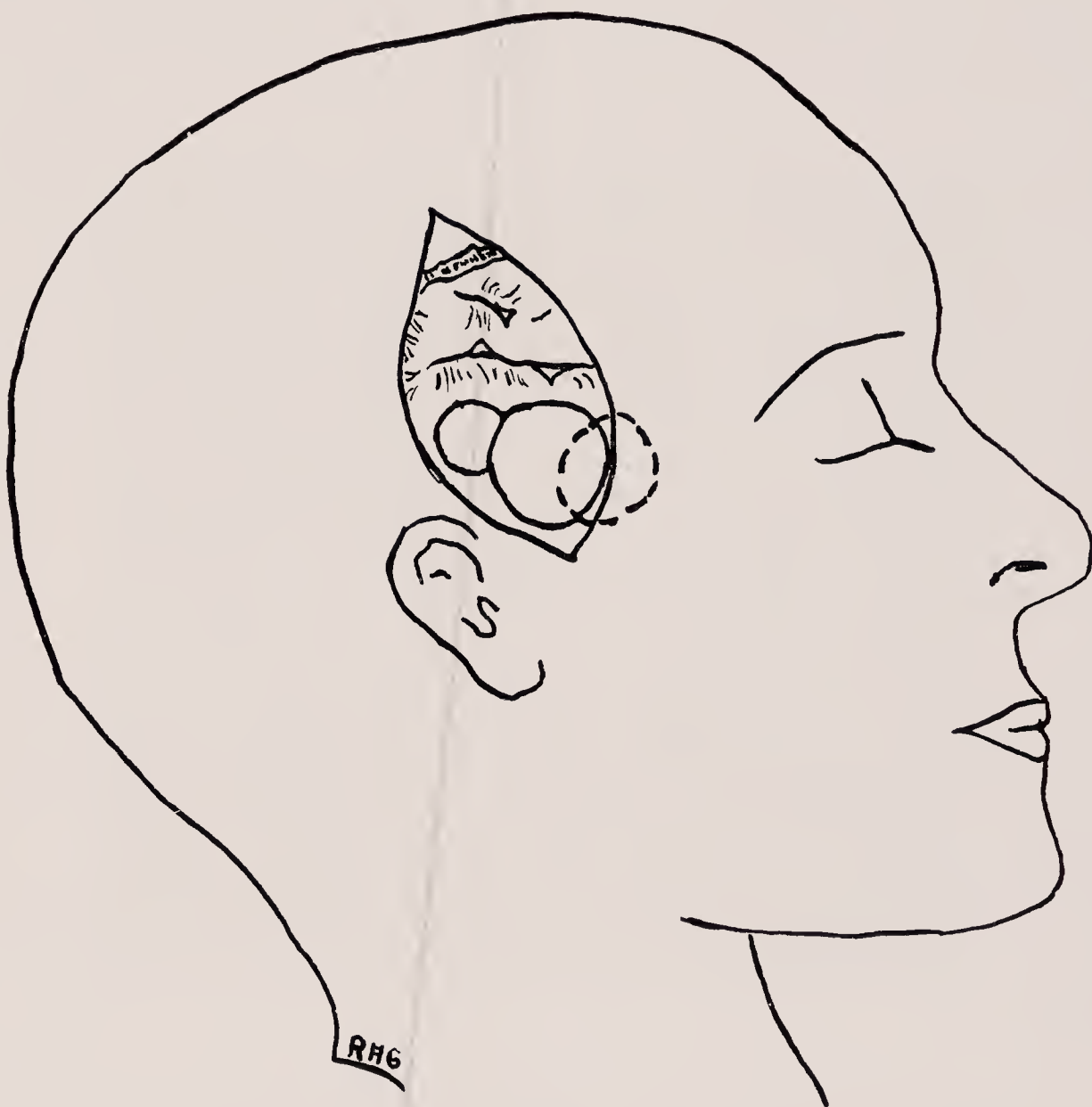


FIG. 6.—Case 5: Schematic diagram showing approximate location of abscesses.

J. R. C., Hosp. No. 35637, male, age 7, was admitted to the University Hospital, March 4, 1937, having been referred by Dr. B. L. Hull, Altoona, Pa. The patient had been well until nine weeks before admission when he fell from an embankment, striking the left frontal bone. He was unconscious at the time of the injury, subsequently regained consciousness and several hours later lapsed into unconsciousness. He remained in this state for 18 days. During this period a hematoma of the scalp developed over the left temple, which became infected, drained for six days and then healed. Five weeks before admission, or four weeks after injury, the patient had several generalized convulsions but improved and was out of bed. Up to one week before admission to the hospital, he had no complaints except that he tired easily. One week before hospitalization, or eight weeks after injury, the patient developed headache, nausea and vomiting. During the next few days these symptoms increased in severity. He became irritable, cried easily and developed weakness of the right face and upper extremity.

*Physical Examination.*—Temperature 99.3° F., pulse 102, respirations 26. The pa-



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of this pus showed many gram-positive Cocci. An attempt was made to enucleate the abscess but the wall was too thin. Sutures were then placed in the wall at its thickest portion. The dura and bone were removed over the lesion. Iodoform packing was placed in the cavity over the abscess and brought out through a separate overlying scalp wound. The remaining dura was sutured in position, the bone flap wired to the skull, and the scalp closed in two layers.

*Postoperative Course.*—The night of the operation, the abscess had pushed its way to the scalp edge, displacing the packing. A suction tip was inserted in a seepage point on the wall and two ounces of pus were removed. The opening in the wall was enlarged and packed tightly with iodoform gauze. Six days later, after signs of infection had subsided, the wall was teased out of its bed through the overlying scalp wound. During this maneuver the ventricle ruptured into the wound. This complication was treated by antiseptics to the surrounding scalp and application of sterile dressings. The cerebrospinal fluid leak continued for ten days and then stopped. Several days later pus was evacuated



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tient was drowsy but could be aroused easily. A scar was present over the left temple. Neurologic examination demonstrated weakness of the right lower face, bilateral choking of four diopters, a paralysis of the right upper extremity and a paresis of the left lower extremity. The reflexes on the right side were decreased and a Babinski was present on the right. White blood count 13,500; urine normal; spinal fluid pressure 750 Mm. of spinal fluid and the fluid contained six lymphocytes per cubic centimeter.

*Operation.*—March 5, 1937: Dr. F. C. Grant made trephines over the left frontal and parietal bones. No hematoma was found but the brain was under marked increased pressure. A cannula was inserted into the brain through the frontal bur opening and increased resistance was encountered at a depth of 3 cm. A third trephine opening was made in the upper limits of a subtemporal decompression. This opening was enlarged to the size of a decompression and the dura opened. During exploration, the patient strained and an abscess (Fig. 6) ruptured into the wound. About an ounce of pus was recovered. The wall was drained by rubber tissue and the wound left open. The pus contained Type I pneumococci on culture.

*Postoperative Course.*—Antipneumococcic serum was administered to the extent of 50,000 units. A cerebral fungus developed, which was amputated seven days after operation. That portion removed contained part of the abscess wall. During the following 24 hours the fungus increased greatly, so that a right subtemporal decompression was performed and the right ventricle tapped. The fungus was explored and the remainder of the original abscess wall removed together with two additional well walled-off abscesses.

The fungus increased in size and drained pus for a number of weeks. Intracranial pressure was reduced by lumbar punctures. These drainages were done as often as every 12 hours during the acute stages. Nine weeks after the last operation, the fungus was clean and had receded sufficiently to allow skin grafting over it. Two weeks later, or three months after admission, the patient was discharged from the hospital.

*Pathologic Examination.*—The abscess wall was composed almost entirely of collagen fibers arranged in parallel rows. Among these fibers were a few glial fibrils and numerous polynuclear leukocytes.

*Subsequent Course.*—One and one-half years later, the patient showed a useful right leg, a less useful right arm and a slight speech defect. These signs were much improved over those recorded when the patient was discharged from the hospital.

**COMMENT.**—The approach to the problem presented by this patient was different from that described in the preceding cases. In exploring for a subdural hematoma, an abscess ruptured into the field of a subtemporal decompression. The only alternative was the institution of drainage. A cerebral fungus quickly developed, was explored, and two well walled-off abscesses found and removed. The cause for the herniation was not only a focal cerebritis but two additional abscesses. Had this herniation not been explored, it is questionable whether this patient would have survived. Therefore, other abscesses as well as a cerebritis may be the cause of cerebral herniation.

**Case 6.**—*Synopsis: Symptoms and signs of intracranial hypertension for one month. Lesion localized to left side by shift of calcified pineal gland, as seen roentgenologically. Abscess in left frontal lobe tapped and drained. Subsequently refilled; attempted removal of wall by craniotomy; rupture of wall; later, removal of two-thirds of wall. Second abscess formed, drained, and complete removal of wall. Third abscess collection developed; wall opened and packed. Recovery.*

M. B., Hosp. No. 132888, male, age 17, was admitted to the Graduate Hospital, January 10, 1938, having been referred by Dr. Henry Dintenfass, Philadelphia, Pa. In August, 1937, this patient had had a right ethmoidectomy. Since that time he complained of generalized weakness. One month before admission to the hospital he developed severe frontal headaches and diplopia on looking to the left. The headaches became progressively

more severe and at the time of his admission, were almost continuous. One week before admission he had an attack of nausea and vomiting, associated with vertigo. From this time on he became increasingly more drowsy.

*Physical Examination.*—This was essentially negative. Temperature 99.6° F., pulse 60, respirations 24. Neurologic examination disclosed a patient mentally quite drowsy; showed a slight right lower facial weakness; a paralysis of the right external rectus; an increase in the reflexes on the left side; and the eyegrounds showed a papilledema of four diopters in both eyes. Roentgenologic examination of the skull demonstrated a calcified pineal gland, which was shifted from the left to the right side of the skull. The examination of the sinuses showed a densely clouded left antrum. *Preoperative Diagnosis:* Left frontal lobe brain abscess.

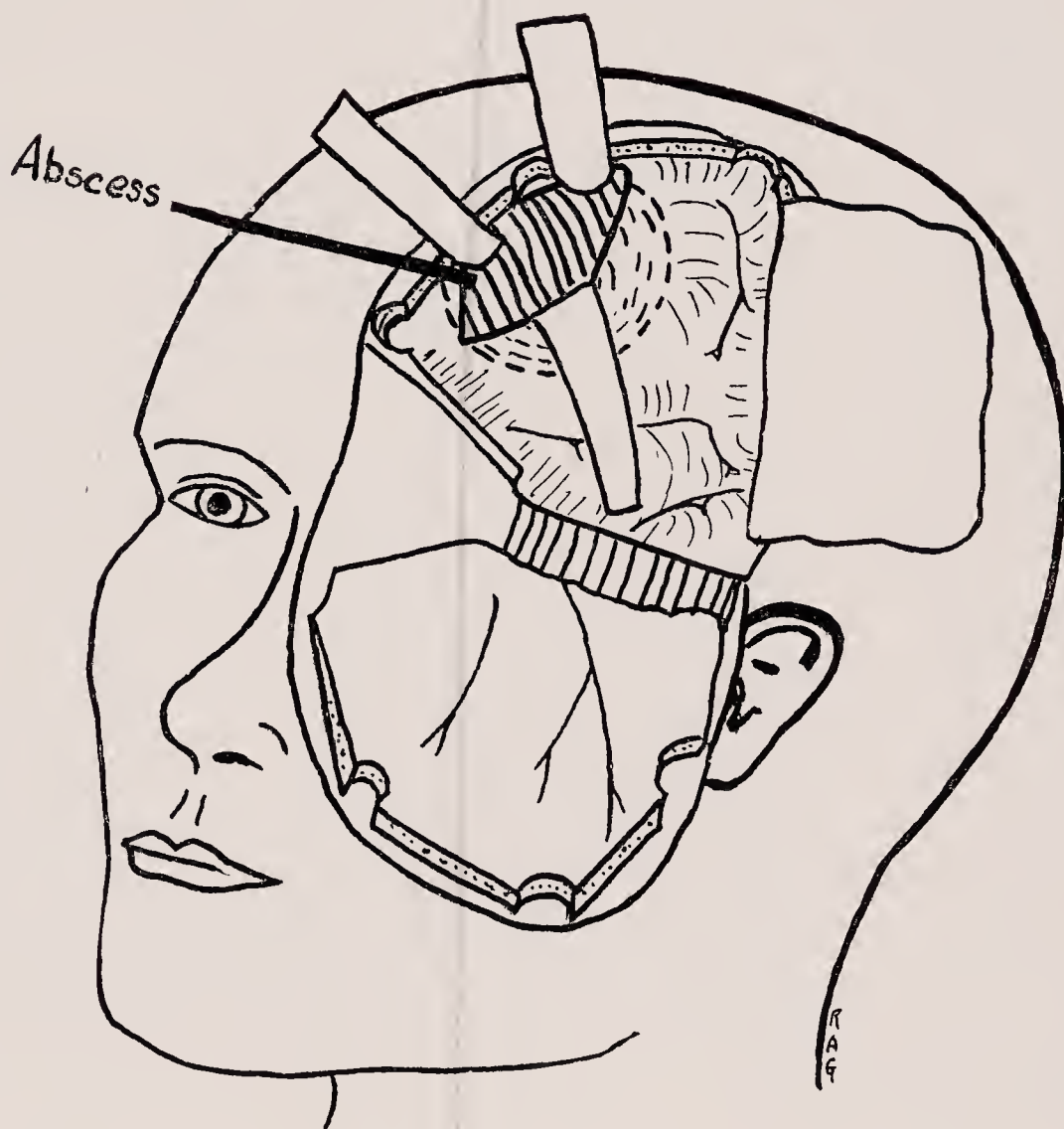


FIG. 7.—Case 6: Schematic diagram showing location of first abscess. The four other abscesses present in this patient were lateral and anterior to this abscess.

*Operation.*—January 12, 1938: Dr. R. A. Groff placed a trephine over the left frontal lobe and an abscess was palpated (Fig. 7) 2 cm. beneath the cortex. The wound was packed with iodoform gauze, and 24 hours later, the abscess was opened and a drainage tube inserted.

*Postoperative Course.*—The abscess continued to drain, and on the eleventh day following the institution of drainage, the eyegrounds showed a sudden increase in papilledema with fresh hemorrhages. A right subtemporal decompression was performed and the left frontal lobe explored through a clean trephine opening but no further pus was obtained. Eight days later, the tube was changed in the abscess and approximately 25 cc. of pus were obtained. Subsequently drainage ceased, the tube was removed, and the patient discharged 45 days after the initial drainage of the abscess.

*Readmission.*—April 15, 1938: Following discharge from the hospital, the patient remained in good condition up until the day before his present admission to the hospital, at which time he developed a continuous headache, became nauseated, and vomited several



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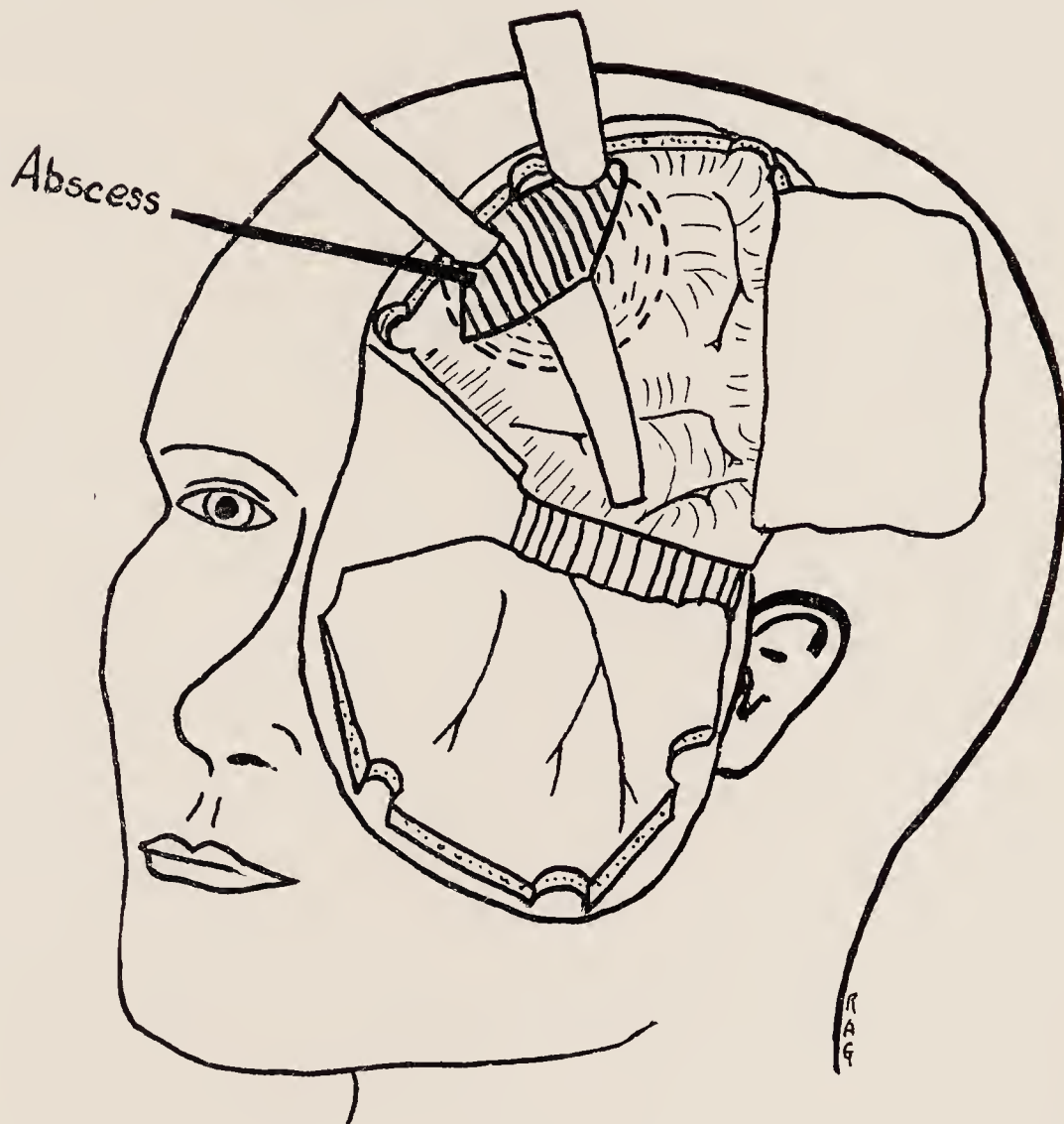


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*Subsequent Course.*—Following this operation, no evidence of meningitis appeared. On the following day, the packing was removed and the abscess wall opened. Approximately 70 cc. of pus were removed. The abscess wall was then packed with iodoform gauze. Following this, drainage continued for several weeks, subsided, and the patient was discharged from the hospital 70 days following the institution of drainage.

*Readmission.*—September 5, 1938: The patient had developed symptoms and signs of a refilling of the abscess.

*Operation.*—September 6, 1938: Dr. R. A. Groff exposed the abscess by opening the scar which had been made previously. Sutures were placed in the wall. The wall was opened and two ounces of pus obtained. The wall was then packed with iodoform gauze. Four days after opening the abscess, the wall was dissected out. Unfortunately, only two-thirds of the wall was obtained. The remaining portion was firmly adherent to the falx. In removing the wall, the ventricle ruptured into the wound. This was treated by light packing. Twenty-six days later the wound was completely healed and the patient was discharged.

*Readmission.*—November 26, 1938: The day before admission the patient had a generalized convulsion. At the time of his admission, the examination was essentially negative except for a small drainage tract at the site where the abscess had been drained. Roentgenograms of the skull demonstrated what was thought to be a beginning osteomyelitis of the bone edge in this vicinity.

*Operation.*—December 3, 1938: Dr. R. A. Groff investigated the sinus tract, and the presumably infected bone was rongeuured away. No evidence of osteomyelitis could be seen. The wound was closed with drainage. The drain was removed on the third day and the discharge ceased on the twelfth day. The patient was discharged 14 days following operation.

*Readmission.*—February 6, 1939: Two weeks before this admission, the patient contracted a cold and was sent to bed by the family physician who diagnosed the illness as "grippe." During succeeding days, decompressed areas became tense and began to bulge. After a period of ten days in bed, patient was pronounced cured of "grippe" and came to hospital because the decompression areas were "hard and tender."

*Operation.*—February 11, 1939: Dr. R. A. Groff performed a ventriculogram which demonstrated a lesion in the left frontal lobe. The scar, through which two previous abscesses had been drained and enucleated, was opened and the abscess wall exposed. The abscess was opened widely, evacuated and packed with iodoform gauze.

The cavity of the abscess stopped discharging two weeks later and began filling-in with fresh granulation tissue.

Three weeks after admission, the ventriculogram was repeated and the defect previously seen was still present but less marked. The patient was discharged six weeks after admission; wound not completely healed.

*Readmission.*—April 4, 1939: Four days before admission, the patient developed a "head cold" and subsequent to this, the decompressed areas became extremely tense. Headaches, nausea and vomiting brought him back to the hospital.

*Operation.*—April 20, 1939: The previous scar was opened by Dr. R. A. Groff. Two



abscess cavities were evacuated of one and one-half ounces of pus. These cavities were opened widely and packed with gauze.

Convalescence was interrupted by a generalized convulsion, nine days after operation. Three days later, packing was removed from cavities, since they were granulating-in rapidly. The decompressed areas became concave for the first time since treatment was started. The wound was practically healed when patient was discharged, May 6, 1939.

Since discharge from the hospital, the patient has remained symptom-free; the wound is well healed and decompressed areas are soft and sunken.

**COMMENT.**—The neurologic findings in this patient were indefinite but seemed to suggest a right frontal lobe lesion. Roentgenograms of the skull disclosed a calcified pineal gland displaced to the right. This evidence definitely placed the lesion on the left side and showed the value of roentgenograms of the skull and the presence of a calcified pineal gland.

The surgical treatment in this patient embodied three methods: Tap and drainage; enucleation; and marsupialization. Rubber drainage proved ineffectual. Enucleation was unsuccessful in the first abscess because the wall was firmly adherent to the falx. Only two-thirds of the wall of this abscess was removed. A second abscess was enucleated in stages. Marsupialization was employed twice for two additional abscesses. This method, described by Horrax,<sup>4</sup> has for its principle uncapping the abscess, fixing the wall to the scalp, and packing.

**Case 7.\***—*Synopsis: History of two head injuries followed by signs of increased intracranial pressure. Two tappings of right frontal lobe abscess. Craniotomy and removal of four encapsulated abscesses. Meningitis. Death.*

W. P., Hosp. No. 36666, male, age 20, was admitted to the Philadelphia General Hospital, April 26, 1937, having been referred by Dr. J. J. Curtin, Philadelphia, Pa. At age 15, the patient had a head injury with loss of consciousness, requiring hospitalization for 30 days. Several weeks following this injury, he became blind in the right eye; was hospitalized and subjected to an encephalogram. The vision in the right eye returned and the patient remained well until November 20, 1936. On this day, the patient struck his head against an iron pipe, became very dizzy, but did not lose consciousness. Two weeks later he developed headache. On December 22, 1936, he had an attack of unconsciousness during which he bit his tongue. This attack lasted 15 minutes and was not associated with convulsive movements. On January 4, 1937, a similar attack occurred and the patient was studied in another hospital for four weeks. He was discharged feeling well. On April 24, 1937, his headaches returned, and he was unable to hold anything on his stomach. His vision became "blurry." He was admitted to this hospital two days later with an increase in symptoms.

**Physical Examination.**—Temperature 99° F., pulse 50. Neurologic examination demonstrated definite clouding of consciousness; tenderness over the right temporal area; and slight blurring of the optic disks. The spinal fluid pressure was 21 Mm.Hg., and the fluid contained 281 cells; 24 per cent of polymorphonuclears and 76 per cent lymphocytes. Roentgenographic studies of the skull and sinuses were essentially negative except for "sclerosis" of the right sphenoid ridge.

**Operation.**—April 30, 1937: Dr. R. A. Groff made a trephine opening over the right frontal lobe just above the fascial attachment of the temporal muscle. An exploratory cannula encountered increased resistance at a depth of 3 cm., anterior and medial to the trephine opening. This mass was penetrated, and 30 cc. of greenish-yellow pus were

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*Postoperative Course.*—The patient recovered rapidly and was discharged. Three weeks later he returned to the hospital with signs of refilling of the abscess. In attempting



FIG. 8.—Case 7: Photograph of the brain showing the area in right lobe from which four abscesses were removed. Note the absence of infection over this area. The infection which terminated patient's life is shown confined to the base of the brain.

to evacuate the abscess for the second time, the cannula would not penetrate the abscess wall because of its thickness. A lumbar puncture was performed. Following this relief of pressure, the symptoms and signs subsided. Operation for removal of the wall was contemplated but the patient refused and left the hospital.

On July 5, 1937, he was admitted to the University Hospital, with symptoms and signs of refilling of the abscess in the right frontal lobe.

*Operation.*—July 6, 1937: Dr. F. C. Grant exposed the right frontal lobe. The abscess was identified, and just as its enucleation had virtually been completed, the wall ruptured. A second abscess was palpated in the temporofrontal lobes and, similarly, as



it was being enucleated, its wall ruptured. Two other abscesses were removed. During the operation a fracture in the posterior wall of the frontal sinus was exposed. The wound was cleansed, the dura closed and the flap and scalp replaced with drainage.

*Postoperative Course.*—Three days later, clinical evidence of meningitis developed, which was confirmed by purulent drainage from the wound and infected spinal fluid. The patient died 16 days after operation.

*Autopsy.*—The brain (Fig. 8) showed evidence of a marked basilar meningitis. The right frontal lobe, from which four abscesses had been removed, showed marked necrosis and destruction, with little evidence of infection. On section of the brain, there was a marked ventriculitis. Microscopic studies of the brain showed a diffuse purulent meningo-encephalitis.

In addition, a fracture was demonstrated extending from the frontal to the ethmoid sinuses. The adjacent bone was infected and these sinuses contained pus. The conclusion from these findings was that the ethmoid and frontal sinuses were the primary focus of infection.

*COMMENT.*—The method of treatment employed in this patient seems to us to be ideal: First, initial tapping of the abscess in order to localize and estimate the thickness of the wall. Second, direct exposure and enucleation of the abscess. The unfortunate circumstance in this patient was the presence of more than one abscess, as well as the osteomyelitic area about the frontal and ethmoidal sinuses which would have, in all probability, continued to reinfect the brain.

*ANALYSIS.*—*Source of Infection:* The source of the infection from which the abscess in the brain developed was unknown in three patients, although in one of these, infected tonsils may have been the contributing factor. The remaining four patients developed a brain abscess during a chronic infection of the frontal and/or ethmoid sinuses. In these latter patients, roentgenographic studies demonstrated the sinus disease, but in no instance was there evidence of osteomyelitis of the bone in or about the sinuses.

*Description of Abscess.*—The locations of the abscesses were: Three in the frontal lobe; two in the temporal lobe; and one each in the occipital and parietal lobes. The depth of the abscesses in relationship to the surface of the brain varied. One lesion presented itself on the surface of the brain and, upon first inspection, was thought to be a meningioma. The remaining lesions were located beneath the surface, varying from a depth of 1 to an extreme distance of 4 cm.

Four patients had single abscesses, whereas the remaining three had multiple abscesses. Where multiple abscesses were present, they were in close relationship to each other and confined to one lobe.

Only one abscess had a stalk. This stalk extended from an infected fracture line involving the frontal and ethmoid sinuses, through the dura to the region of the abscesses in the frontal lobe. Four abscesses were present in this patient.

All abscesses had walls which were sufficiently firm to permit enucleation.

*Diagnosis and Treatment.*—The preoperative diagnosis in these seven patients influenced the method of treatment. In four cases (Cases 1, 2, 3 and



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4), the primary diagnosis was brain tumor and in two of these cases (Cases 1 and 2), brain abscess was not considered a possibility. All four patients were subjected to a ventriculogram, when localization could not be made clinically, and then to a craniotomy. When the diagnosis of brain abscess had not been considered, the lesion was enucleated. That the lesion was an abscess was not appreciated until it was sectioned in the laboratory. When the diagnosis of abscess had been made preoperatively, a needle was introduced into the lesion after exposure had been made. Enucleation was performed immediately after the tapping in the one patient, whereas, in the second patient, the abscess was removed several days following the craniotomy.

A fifth patient (Case 5) was diagnosed a chronic subdural hematoma. After exploratory trephines had been made, a subtemporal decompression was carried out. An abscess ruptured into the operative field during this procedure. Subsequently, the wall of the ruptured abscess, together with two additional intact abscesses, was removed.

The diagnosis of the remaining two patients (Cases 6 and 7) was made preoperatively. After preliminary tapping and rubber tube drainage had been performed unsuccessfully, both were subjected to a craniotomy. The wall of the abscess was so firmly adherent to the falx in one patient (Case 6) that it ruptured while attempting to remove it. Part of the wall was removed a few days later. Several months afterward, a second abscess became apparent; this was drained and the wall removed completely. Approximately six months later, two abscesses were localized and treated by marsupialization.

The last patient (Case 7) had four abscesses, two of which ruptured during removal. One of these abscesses had a stalk which connected with an infected fracture line in the frontal and ethmoid sinuses. This stalk was disturbed during the operation and meningitis terminated the patient's life. This is the only death in this series.

*Complications.*—The only complication in the four patients with a single abscess was an osteomyelitis of the bone flap. This unfortunate circumstance could have been avoided, since it was the direct result of the operator's (R. A. G.) overlooking a sponge. The complication which arose in the treatment of the patients with multiple abscesses was meningitis in one patient. This was the result of a disturbance of the stalk of one of the abscesses and, in addition, the rupture of two abscesses during removal. In another patient, a cerebral herniation resulted, and within this mass two walled-off abscesses were found and removed.

*COMMENT.*—The smooth, rapid and uncomplicated convalescence in the four patients with single abscesses, if one overlooks the avoidable complication of osteomyelitis of the bone flap in the one patient, commends this procedure as the most satisfactory treatment for brain abscesses which have a firm wall. The complications of cerebral herniation, cerebral fungus, and an alarming increase in intracranial pressure are avoided. The constant wound care necessitated, when drainage methods are employed, is eliminated. The postoperative care is reduced to the management of a patient who has been operated

upon for a brain tumor, and the morbidity rate in these patients, at the present writing, is extremely low. These facts justify the surgical procedure of enucleation of a well walled-off brain abscess.

The term "capsule" has been purposely discarded, because the meaning conveyed by it is a covering for organs, or certain tumors. The layer of tissue about an abscess is a barrier to enclose or confine the infection. This barrier or wall is not a capsule nor is it referred to as such in abscesses in other parts of the body. We are in accord with Atkinson,<sup>5</sup> that the tissue surrounding an abscess should be called the "wall."

The enucleation of a brain abscess by direct exposure depends upon the firmness of the abscess wall. Therefore, this fact must be known before enucleation is contemplated. The most practical way in which this information can be determined is by exploration with a cannula through a trephine opening. If the cannula imparts the information that the wall is firm, enucleation of the abscess by direct exposure can be carried out immediately. On the other hand, if the cannula passes through the wall without much resistance, it will be necessary to adopt measures to allow more time, in order that the wall of the abscess may become firmer and thicker. These measures may be one of several; repeated tapplings of the abscess, such as was done in Case 7; or repeated tapplings and a subtemporal decompression, in order to control increase in intracranial pressure and save vision, as was carried out in Case 6. A craniotomy may be performed without opening the dura, as suggested by Vincent. The latter method was utilized in a modified form in Case 4. In this patient, after the abscess had been exposed, it was found that the wall was not thick enough to permit enucleation. The abscess was removed several days later.

Tapping the abscess gives the additional information of the type of organism which is responsible for the infection. If this organism is one of those susceptible to the several chemotherapeutic agents, they can and should be given, as suggested by Rowe<sup>6</sup> and Bucy.<sup>7</sup>

Multiple abscesses of the brain present a different problem. The three cases presented here were more or less ideal in that the abscesses were grouped together. Two of these patients were treated successfully; the third died of meningitis. The difficulty with this problem is that the walls of the several abscesses are not in the same stage of development. Thus, if a preliminary tap is made and the cannula strikes an abscess with a firm wall, and direct exposure discloses several lesions, one or more of them may not have a wall which is firm and sufficiently thick to remove without rupture.

Abscesses resulting from penetrating wounds and direct extension of the infection from either an infected mastoid or frontal sinus cannot be treated by this method. The one patient in this series (Case 7), whose lesion had a stalk leading from an infected frontal and ethmoid sinus, died from meningitis as a result of disturbance of this tract. The methods of King,<sup>8</sup> Horrax<sup>4</sup> and Kahn<sup>3</sup> are more applicable for treating this type of pathology.



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SUMMARY

The records of seven patients with brain abscess, in whom the surgical treatment was enucleation by direct exposure, have been presented.

The reasons for considering the method of enucleation of firmly walled-off brain abscesses as the most satisfactory form of treatment have been given.

The problems which arose in connection with this method of treatment have been discussed, and an outline has been given for the management of patients in whom the diagnosis of brain abscess has been made.

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## THE TREATMENT OF ADDISON'S DISEASE BY THE IMPLANTATION OF SYNTHETIC HORMONE\*

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It is highly probable that human beings have died from destruction of their adrenal glands since the beginning of the race, but the clinical picture incident to this destruction has been recognized for only 84 years, and the physiologic alterations that are induced by adrenal disease have been understood for less than 10 years. Finally, a crystalline substance which rectifies these alterations, which abolishes the symptoms, and prevents death, has been available for less than two years. It is the purpose of this communication to tell of 17 patients who have been given this specific substance in the form of pellets implanted subcutaneously.

Since 1855, it has been known that destructive lesions of the adrenal glands cause weakness, loss of weight, hypotension, digestive disturbances, pigmentation and death. An excerpt from Addison's<sup>1</sup> original paper will suffice to show how clearly he grasped the essential features of the syndrome resulting from adrenal insufficiency:

"The patient, in most of the cases I have seen, has been observed gradually to fall off in general health; he becomes languid and weak, indisposed to either bodily or mental exertion; the appetite is impaired or entirely lost; the whites of the eyes become pearly; the pulse small and feeble, or perhaps somewhat large, but excessively soft and compressible; the body wastes without, however, presenting the dry and shriveled skin and extreme emaciation usually attendant on protracted malignant disease; slight pain or uneasiness is from time to time referred to the region of the stomach, and there is occasional actual vomiting, which in one instance was both urgent and distressing; and it is by no means uncommon for the patient to manifest indications of disturbed cerebral circulation." . . . "We discover a most remarkable and, so far as I know, characteristic discoloration taking place in the skin—sufficiently marked, indeed, as, generally, to have attracted the attention of the patient himself, or of the patient's friends.

"The disease develops in the third or fourth decade of life, usually quite insidiously, with adynamia and apathy. To these are added disturbances of the digestive tract (constipation, often alternating with diarrhea), and pigmenting of the skin and mucous membranes: the patients succumb under a gradually increasing cachexia, not rarely with stormy terminal manifestations; autopsy almost always shows disease of both suprarenals, mostly tuberculous caseation."

Addison not only gave to the world a concise description of the disease

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